Silicon Micromachining for Millimeter- and Submillimeter-Wave Applications

Completed Technology Project (2017 - 2018)

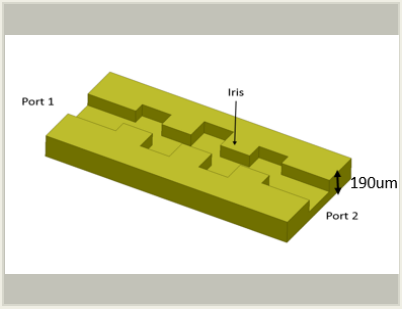
Project Introduction

The molecular and atomic transitions observed in the THz frequency range provide a wealth of information for astrophysics, as well as earth and planetary science. As science goals drive coherent guided wave technologies from the microwave into submillimeter devices, manufacturing tolerances are correspondingly tightened. Increasingly, the accuracy achievable by traditional precision metal fabrication techniques is insufficient to reliably define waveguide filter characteristics. In the proposed effort, we plan to use silicon micromachining techniques to demonstrate the fabrication of narrow bandpass filters at 220.5 GHz and 682.5 GHz. This approach will be used for development of future components used in suborbital and satellite instrument systems for THz remote sensing.

Anticipated Benefits

The earth science decadal survey recommended an advanced science payload with submillimeter-wave and long-wave infrared (LWIR) radiometers for ice-cloud measurements. Direct detection radiometers at high frequencies can significantly reduce size, mass, power, and cost of future instruments. SWIRP (Compact Submm-Wave and LWIR Polarimeters for Cirrus Ice Properties) is a dual-polarized radiometric instrument incorporating 220.5 GHz and 682.5 GHz channels. Each receiver channel requires bandpass filters with very small center frequency drift error to mitigate contributions from other atmospheric constituents. Currently, the 682.5 GHz waveguide filters have not been successfully fabricated and represent a high-risk component threatening the architecture within the SWIRP design and similar envisioned future projects.

More broadly, this work supports the technology needs for heterodyne spectrometry, which requires high-precision waveguide and channels to integrate passive and active components. Examples include the heterodyne spectrometer for the Europa lander mission for the detection of the 2.5 THz OH line, and for astrophysics THz heterodyne applications including SOFIA, GUSTO, LBR and STO2. Moreover, this effort can potentially advance the ongoing need to integrate semiconductor Quantum Cascade Lasers (QCL) and realize efficient coherent THz sources.



Sample filter block.

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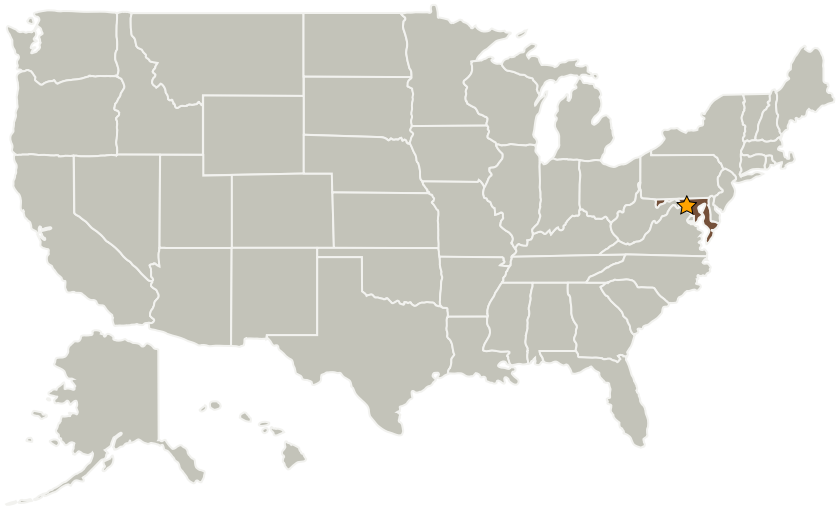
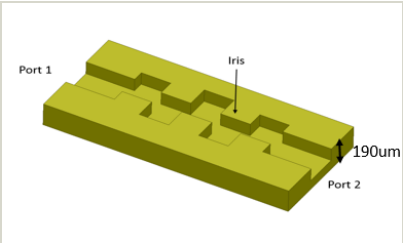
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland

Primary U.S. Work Locations
Maryland

Images



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(https://techport.nasa.gov/image/28316)

Organizational Responsibility

Responsible Mission Directorate:
Mission Support Directorate (MSD)

Lead Center / Facility:
Goddard Space Flight Center (GSFC)

Responsible Program:
Center Independent Research & Development: GSFC IRAD

Project Management

Program Manager:
Peter M Hughes

Project Managers:
Terence A Doiron
Michael A Johnson

Principal Investigator:
Manuel Vega

Co-Investigators:
Berhanu T Bulcha
Dongliang Wu
Edward J Wollack

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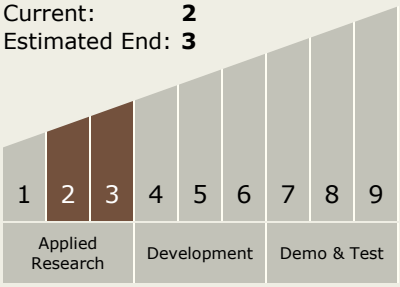
Technology Maturity (TRL)

Start: **2**
Current: **2**
Estimated End: **3**



Technology Areas

Primary:

- TX08 Sensors and Instruments
  - TX08.1 Remote Sensing Instruments/Sensors
    - TX08.1.4 Microwave, Millimeter-, and Submillimeter-Waves

Target Destinations

Earth, Others Inside the Solar System, Foundational Knowledge